RISK FACTOR MODELLING FOR FOREST YIELD PREDICTIONS IN ALBERTA, CANADA

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ABSTRACT. The boreal forest is a major forest region of Canada, comprising approximately 82% of the forest land in the country. Various risk factors cause errors in prediction and realization of annual allowable cut. A conceptual model was developed to simulate projected expectations, as the probability of losses due to such occurrences are usually predictable for large areas within a given time frame. Preliminary results of such modelling are presented for the McLeod Working Circle in west-central Alberta.

INTRODUCTION

Boreal tree species are of vital importance in the production of sawlogs and pulpwood in Canada; however, forest yields are vulnerable to many risk factors. Forest fires are a common occurrence and often result in destruction of large areas of growing stock. In Alberta, fires have caused an average annual forest area loss of nearly 0.5% over the past two decades. In addition, there are mortality and reduction in growth due to insects and disease infestations.

These problems have not so far been quantified objectively in resource allocation and management, mainly because of a general lack of available tools for such predictions. Many sources of uncertainty affect potential returns and can result in sub-optimal decisions concerning timber supply projections (Marshall 1987). Improved techniques are needed to ensure realistic predictions. Reed and Errico (1986) and Stevens (1986) have developed procedures for optimal harvest scheduling when fire risk is present in western Canada.

The objectives of the risk factor study in the boreal forest of Alberta were: 1) to model the risk of fire to aid management decisions on allowable cut and future timber supplies; 2) to determine the frequency of large-scale insect and disease occurrences and derive a model to assess their impact on the present and future forest yields; and 3) to develop a fire and disease risk factor growth and yield prediction model applicable over the boreal forest ecoregions.

STUDY AREA AND METHODS

BOREAL FOREST REGION

The boreal forest of North America extends as a continuous belt of predominantly coniferous trees from Newfoundland to the Rocky Mountains and Alaska (Rowe 1972). In western Canada, the boreal region is usually divided from south to north into three subregions (Maini 1968, Singh and Powell 1986):

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1. Forest-grassland transition: occupied primarily by trembling aspen (Populus tremuloides Michx.), willows (Salix spp.), snowberry (Symphoricarpos albus (L.) Blake), and grasses.

2. Predominantly forest: consisting mainly of white spruce (Picea glauca (Moench) Voss), black spruce (P. mariana (Mill.) B.S.P.), balsam fir (Abies balsamea (L.) Mill), jack pine (Pinus banksiana Lamb.), trembling aspen, and white birch (Betula papyrifera Marsh.).

3. Forest-tundra transition: consisting mostly of open-canopied white and black spruce stands, dwarf birch (Betula glandulosa Mich.), black crowberry (Empetrum nigrum L.), and lichens and mosses.

RISK FACTOR DATA

Development of the risk factor model for forest yield prediction was based on Alberta data. The McLeod Working Circle, in the leasehold of Champion Forest Products Ltd., was selected for the formulation and development of the model. The currently available data on risk factors and growth and yield were collated and examined through necessary data screening procedures. Historic data were retrieved from provincial records on fire and disease occurrences.

MODEL DEVELOPMENT

A total of 4 years was estimated to cover all stages of the study. The stages in the development of FOrestry RIsk Model (FORIM) include:

I. Initial stage: A review of risk and uncertainty factors n growth and yield due to fire and insect and disease occurrences, collection and evaluation of data relating to such fact rs.

II. Preliminary development stage: Preliminary attempts at development of a conceptual model dealing with risk factors relating to growth and yield.

III. Intermediary stage: Implementation of model concepts and strategies to achieve parameter estimation and calibration.

IV. Refinement stage: Improvement and refinement in risk factor model and parameter estimates to enhance model capabilities, and a validation test on independently collected and most recent data in a similar ecoregion in western Canada.

V. Final stage: Finalizing the risk factor model and its components for the boreal forest, and recommendations for its extention to disjunct outliers or ecoregions, including preparation of a manual for operational use and guidelines to prescribe needed management plans and timber harvesting strategies.

A work plan was devised for the expected 4 years of the study and goals were identified for each year according to the various stages described above.

PRELIMINARY VERSION OF MODEL (FORIM-1)

The work conducted under stages I and II during the current year includes preliminary development of the model under two main components: 1) forest yield prediction module, and 2) allowable cut module. As the names imply, the first module is to provide yield table information and the second module is to serve the planning requirements involved in annual alowable cut determination.

RESULTS AND DISCUSSION

FORIM-1 was produced through a contract under the Canada-Alberta Forest Resource Development Agreement (Dempsters and Stevens 1987). The main subroutines and tasks related to each are briefly described below for the major components.

FOREST YIELD PREDICTION

The input information and data needed for the model are read with the help of RDRUN, RDCOEF, RDAREA, and RDRISK subroutines (Fig. 1). These inputs are:

RDRUN - computer run parameters set during the execution of front-end of the program

RDCOEF - coefficients for height, site index, volume, years to stump, and breast height predictions

RDAREA - compartment area

RDRISK - probabilities of fire and insect and disease destruction

The subroutines used for computing and providing outputs are CALPO, GETAGE, SISRCH, HTCALC, VCALC, SUM, SUMPO, and YLDSUM. The tasks performed by these subroutines are:

CALPO - determines the cumulative probability of survival for fire and insect and disease risks

GETAGE - calculates breast height age

SISRCH - estimates site index from height and age

HTCALC - calculates vector of predicted heights from age at base date to end of projection period

VCALC - calculates volume from type and density under risk constraints

SUM - sums the vectors to provide precision estimates of volume at base age

SUMPO - calculates combined cumulative probability of survival and annual probability of destruction

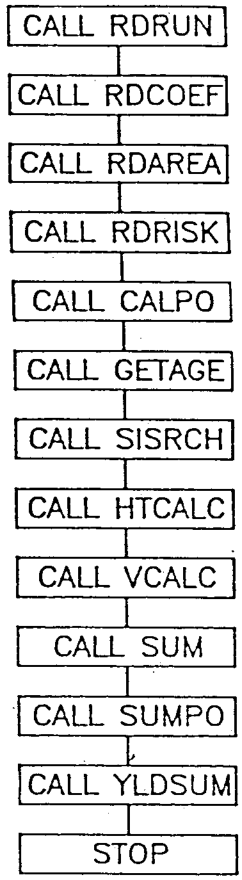

Fig. 1 Forest yield prediction subroutines

YLDSUM - summarizes the regeneration and fire-origin growth projections averaged over the plots

ANNUAL ALLOWABLE CUT COMPUTATION

The annual allowable cut module uses RDRUN and RDTAB subroutines to read input on run parameters and yield table information. Various required computations in this module are done by the following subroutines:

MANSEQ - Calculates the average of yield projections for subcompartments grouped together in a run sequence

MAXAGE - sorts compartments in descending order of age

AUTOSQ - automatically sequences compartments based on age

PROBAV - performs area/volume check by using maximum annual volume loss as a criterion for harvest compartments

GETCMP - determines which compartment will be cut first on the basis of maximum annual volume loss

AV - performs area-volume check

PRINT - prints required information

The choice of the subroutines to be used is made according to the type of run requested (Fig. 2).

RISK ANALYSIS OUTPUT

The fire rates used and the expected average annual yields under different rotations (80, 90, and 100 years) and fire severity classes are shown in Table 1. Absence of data on the reduction of growth rates and mortality caused by insect and disease infestations precluded the use of the model to assess these effects. On the basis of fire as a major risk factor, however, the results clearly showed that rotation length and fire risk severity have significant effect on annual forestry yields. The expected yields increased 8.3, 9.7, and 11.1% when rotation age was reduced by 10 years for mild, medium, and severe fire rates, respectively. Cumulative probability of realization of expected average annual yield is shown in Table 2. The range of risk involved increases with increase in rotation period.

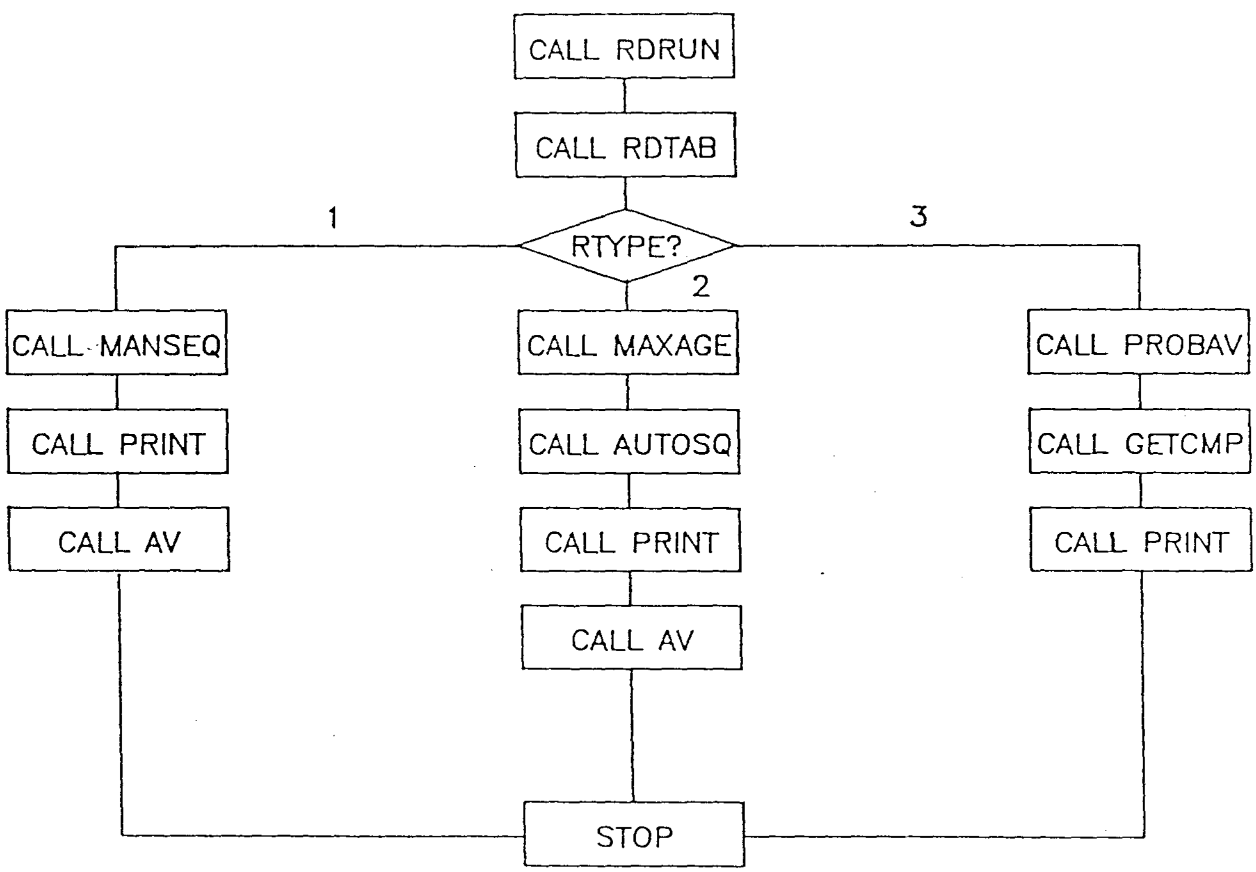

Fig. 2. Annual allowable cut subroutines.

Awareness of forestry risks and their adverse effects on forest growth and yield can play an increasingly important role in future management and prediction of timber supplies. Reducing rotation age and proper risk management have beneficial effects on expected annual yields. The preliminary work done on the risk factor model in this study holds promise for improved management and utilization of forestry resource in western Canada.

Table 1. Average annual yield (m^3) predicted by the risk factor model under historical boreal forest fire rates of Alberta

Fire Severity	Rotation (years)		
	80	90	100
1. Mild (0.26%)	361,551	335,519	305,214
2. Moderate (0.40%)	342,713	312,295	285,690
3. Severe (0.70%)	306,613	275,938	249,264

Table 2. Cumulative probability of realization of expected volume under different rotations and fire severity conditions.

Fire Severity	Rotation (years)		
	80	90	100
1. Mild (0.26%)	0.813-0.998	0.792-0.998	0.772-0.998
2. Moderate (0.40%)	0.727-0.997	0.699-0.997	0.671-0.997
3. Severe (0.70%)	0.572-0.995	0.534-0.995	0.497-0.994

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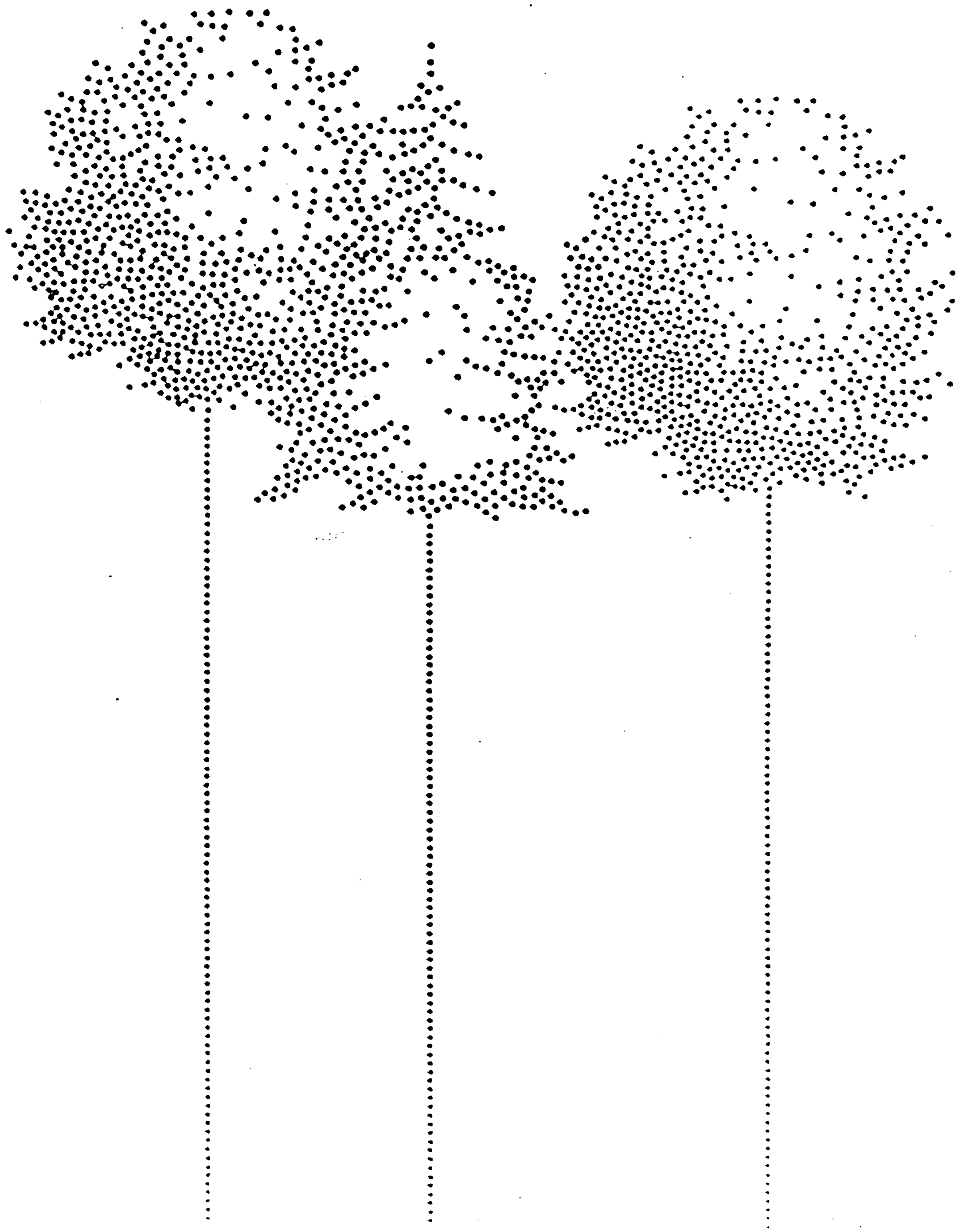

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